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First Named Inventor	JULIA MACLACHLAN
Art Unit	1733
Examiner Name	JESSICA ROSSI
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ENCLOSURES *(Check all that apply)*

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  - [ ] Fee Attached
- [ ] Amendment/Reply
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  - [ ] Affidavits/declaration(s)
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re Application of: Julia MacLachlan

Serial No: 09/997,347

Filed: November 29, 2002

For: METHOD OF USING SHORT WAVELENGTH UV LIGHT TO SELECTIVELY REMOVE A COATING FROM A SUBSTRATE AND ARTICLE PRODUCED THEREBY

Group Art Unit: 1733

Examiner: Jessica Rossi

Attorney Docket No: 1-15092

MAIL STOP APPEAL BRIEF – PATENTS
Commissioner for Patents
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BRIEF ON APPEAL

Honorable Sir:

This brief is in furtherance of the Notice of Appeal, which was timely filed in connection with the above-captioned application on August 1, 2005, the Notice of

Appeal being received in the PTO on August 4, 2005. This Brief is being filed under the provisions of 37 CFR §41.37 and its related requirements.

A separate Petition for Extension of Time Under 37 CFR §1.136(a) is included herewith. The fees required under 37 CFR 1.17(F) are also being submitted herewith.

1. Real Party in Interest

The real party in interest in Pilkington North America, Inc. The assignment to Pilkington North America, Inc. was recorded on November 29, 2001, at reel 012345, frame 0075.

2. Related Appeals and Interferences

There is no known appeal or interference which will directly affect, or be directly affected by, or have a bearing on, the Board's decision in this Appeal.

3. Status of Claims

On August 1, 2005, applicant submitted a Notice of Appeal in connection with the subject application, appealing the final rejection of claims 23-38.

The status of each of the claims is as follows:

1. Claims cancelled: 1-22;
2. Claims withdrawn from consideration but not cancelled: None;
3. Claims pending: 23-38;
4. Claims allowed: None;
5. Claims rejected: 23-38.

The claims on appeal are 23-38. A copy of the claims on file is submitted in the attached Claims Appendix.

4. Status of Amendments

No amendment was filed subsequent to the final rejection of the application by the Office Action of July 18, 2005.

5. Summary of Claimed Subject Matter

The present invention, as defined by independent claims 23, defines a method of adhering an item 24 to an area 20 of an exterior surface 12 of the exterior of a vehicle glazing on which a hydrophobic coating has previously been disposed. In order to securely adhere the item 24, e.g., an item of hardware, to the surface 12 of the glass sheet or panel comprising the exterior surface 12 of vehicle glazing, the hydrophobic coating must be selectively removed. Precise removal of the hydrophobic coating is accomplished by irradiating the selected area with short wavelength UV radiation having a dominant wavelength in the range of 100 nm to 200 nm.

The item may then be adhered to the area 20 of the exterior surface 12 of glass sheet or panel from which the hydrophobic coating has been removed by a suitable method.

The invention as defined in claim 23 is best illustrated in Fig. 1, showing the coated glass (10,12) being exposed to the short wavelength UV light, the UV radiation emanating from a device 14, preferably an excimer lamp. Fig. 2 shows the coated glass (10,12) after exposure to the short wavelength UV light, so that area 20 is substantially free of the hydrophobic coating 12. Fig. 3 shows an item of hardware 24 adhered by a suitable adhesive 22 to the area 20 from which the hydrophobic coating was removed. Figs. 4 and 5 show the water contact angle 26 of a water droplet relative to the surface of the glass sheet before (Fig. 4) and after (Fig. 5) the removal of the hydrophobic coating.

Support for the present invention as defined in claim 23, can be found throughout the specification of the subject application, but in particular page 2, paragraphs 4 and 5 (Summary of the Invention). The Detailed Description of the Invention, beginning at page 3, through page 5, paragraph 3, further describes the invention.

6. Grounds for Rejection to be Reviewed on Appeal.

On July 18, 2005, the Examiner issued a second Office Action in connection with the RCE application filed by applicant on October 18, 2004. This Office Action was made final. While the Examiner did withdraw several rejections in light of applicant's Amendment of May 9, 2005, the Examiner, nonetheless, maintained a significant number of rejections of all of the pending claims, namely, claims 23-38.

a) Claims 23-24 and 26-33 were rejected under 35 USC 103(a) as being unpatentable over JP 2001-146439 to Yoshinori et al., in view of U.S. Patent No. 4,543,283 to Curtze et al. and U.S. Patent No. 5,556,667 to Teranishi et al.

b) Claim 25 was rejected under 35 USC 103(a) as being unpatentable over JP 2001-146439 to Yoshinori et al., U.S. Patent No. 4,543,283 to Curtze et al. and U.S. Patent No. 5,556,667 to Teranishi et al., and further in view of U.S. Patent No. 5,763,892 to Kizaki et al.

c) Claims 34-35 and 37-38 were rejected under 35 USC 103(a) as being unpatentable over JP 2001-146439 to Yoshinori et al., U.S. Patent No. 4,543,283 to Curtze et al. and U.S. Patent No. 5,556, 667 to Teranishi et al., and further in view of the collective teachings of U.S. Patent No. 5,131,967 to Tweadey et al. and U.S. Patent No. 4,931,125 to Volkmann et al.

d) Claim 36 was rejected under 35 USC 103(a) as being unpatentable over JP 2001-146439 to Yoshinori et al., U.S. Patent No. 4,543,283 to Curtze et al., U.S. Patent No. 5,556,667 to Teranishi et al. and the collective teachings of U.S. Patent No. 5,131,967 to Tweadey et al. and U.S. Patent No. 4,931,125 to Volkmann et al., and further in view of U.S. Patent No. 5,673,892 to Kizaki et al.

e) Claims 23-24 and 26-33 were rejected under 35 USC 103(a) as being unpatentable over the prior art referred to in U.S. Patent No. 5,556,667 to Teranishi et al., in view of U.S. Patent No. 4,543,283 to Curtze et al. and JP 2001-146439 to Yoshinori et al., and/or U.S. Patent No. 6,316,059 to Van Der Putten et al.

f) Claim 25 was rejected under 35 USC 103(a) as being unpatentable over U.S. Patent No. 5,556,667 to Teranishi et al., U.S. Patent No. 4,543,283 to Curtze et al., and JP 2001-146439 to Yoshinori et al., and/or U.S. Patent No. 6,316,059 to Vander Putten et al.

g) Claims 34-35 and 37-38 were rejected under 35 USC 102(a) as being unpatentable over U.S. Patent No. 5,556,667 to Teranishi et al., U.S. Patent No. 4,543,283 to Curtze et al. and JP 2001-146439 to Yoshinori et al., and/or U.S. Patent No. 6,316,059 and further in view of the collective teachings of U.S. Patent No. 5,131,967 to Tweadey et al., and U.S. Patent No. 4,931,125 to Volkmann et al.

h) Claim 36 was rejected under 35 USC 103(a) as being unpatentable over U.S. Patent No. 5,556,667 to Teranishi et al., U.S. Patent No. 4,543,283 to Curtze et al., JP 2001-146439 to Yoshinori et al., and/or U.S. Patent No. 6,316,059 to Vander Putten et al., and the collective teachings of U.S. Patent No. 5,131,967 to Tweadey et al., and U.S. Patent No. 4,931,125 to Volkmann et al., and further in view of U.S. Patent No. 5,763,892 to Kizaki et al.

i) Claims 23-24 and 26-33 were rejected under 35 USC 103(a) as being unpatentable over FR 2793889 to Anderson, in view of U.S. Patent No. 4,543,283 to Curtze et al. and also in view of JP 2001-146439 to Yoshinori et al. and/or U.S. Patent No. 6,316,059 to Vander Putten et al.

j) Claim 25 was rejected under 35 USC 103(a) as being unpatentable over FR 2793889 to Anderson, U.S. Patent No. 4,543,283 to Curtze et al. and JP 2001-146439 to Yoshinori et al. and/or U.S. Patent no. 6,316,059 to Vander Putten et al. and further in view of U.S. Patent No. 5,763,892 to Kizaki et al.

k) Claim 34-35 and 37-38 were rejected under 35 USC 103(a) as being unpatentable over FR 2793889, U.S. Patent No. 4,543,283 to Curtze et al. and JP 2001-146439 to Yoshinori et al., and/or U.S. Patent No. 6,316,059 to Vander Putten et. al., and further in view of the collective teachings of U.S. Patent No. 5,131,967 to Tweadey et al., and U.S. Patent No. 4,931,125 to Volkmann et al.

l) Claim 36 was rejected under 35 USC 103(a) as being unpatentable over FR 2793889 to Anderson, U.S. Patent no. 4,543,283, JP 2001-146439 to Yoshinori et al., and/or U.S. Patent No. 6,316,059 to Vander Putten et al., and the collective teachings of U.S. Patent No. 5,131,967 to Tweadey et al., and U.S. Patent No.

4,931,125 to Volkmann et al., and further in view of U.S. Patent No. 5,763,892 to Kizaki et al.

m) Claims 23-24 and 26-33 were rejected under 35 USC 103(a) as being unpatentable over U.S. Patent No. 4,983,459 to Franz et al. et al., in view of U.S. Patent No. 4,543,283 to Curtze et al., and also in view of JP 2001-146439 to Yoshinori et al., and/or U.S. Patent No. 6,316,059 to Vander Putten et al.

n) Claim 25 was rejected under 35 USC 103(a) as being unpatentable over U.S. Patent No. 4,983,459 to Franz et al. et al., U.S. Patent No. 4,543,283 to Curtze et al. et al., and JP 2001-146439 to Yoshinori et al., and/or U.S. Patent No. 6,316,059 to Vander Putten et al. and further in view of U.S. Patent No. 5,763,892 to Kizaki et al.

o) Claims 34-35 and 37-38 were rejected under 35 USC 103(a) as being unpatentable over U.S. Patent No. 4,983,459 to Franz et al., U.s. Patent No. 4,543,283 to Curtze et al., JP 2001-146439 to Yoshinori et al., and/or U.S. Patent No. 6,316,059 to Vander Putten et al., and further in view of the collective teachings of U.S. Patent No. 5,131,967 to Tweadey et al., and U.S. Patent No. 4,931,125 to Volkmann et al.

p) Claim 36 was rejected under 35 USC 103(a) as being unpatentable over U.S. Patent No. 4,983,459 to Franz et al., U.S. Patent No. 4,543,283 to Curtze et al., JP 2001-146439 to Yoshinori et al., and/or 6,316,059 to Vander Putten et al., and the collective teachings of U.S. Patent No. 5,131,967 to Tweadey et al., and U.S. Patent No. 4,931,125 to Volkmann et al., and further in view of U.S. Patent No. 5,763,892 to Kizaki et al.

q) Claim 25 was rejected under 35 USC 103(a) as being unpatentable over U.S. Patent No. 5,556,667 to Teranishi et al., U.S. Patent No. 4,543,283 to Curtze et al. and JP 2001-146439 to Yoshinori et al. and/or U.S. Patent No. 6,316,059 to Vander Putten et al. and further in view of U.S. Patent No. 5,763,892 to Kizaki et al.

r) Claims 34-35 and 37-38 were rejected under 35 USC 103(a) as being unpatentable over U.S. Patent No. 5,556,667 to Teranishi et al., U.S. Patent No. 4,543,283 to Curtze et al. and JP 2001-146439 to Yoshinori and/or U.S. Patent No. 6,316,059 to Vander Putten and further in view of the collective teachings of U.S. Patent No. 5,131,967 to Tweadey et al. and U.S. Patent No. 4,931,125 to Volkmann et al.

s) Claim 36 was rejected under 35 USC 103(a) as being unpatentable over U.S. Patent No. 5,556,667 to Teranishi et al., U.S. Patent No. 4,543,283 to Curtze et al., JP 2001-146439 to Yoshinori et al. and/or U.S. Patent No. 6,316,059 to Vander Putten et al. and the collective teachings of U.S. Patent No. 5,131,967 to Tweadey et al. and U.S. Patent No. 4,931,125 to Volkmann et al.

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7. Argument.

In view of the numerous grounds of rejection, and in order to facilitate the Board's review of applicant's arguments relative to the cited references, applicant provides the following brief summary of same:

JP 2001-146439 to Yoshinori et al., is believed to describe a method of partially removing a functional coating. Part of the coating is protected to avoid its exposure to UV light. The portion of the coating which is exposed to the UV light is broken down to generate ozone which is utilized in a later film removal step.

U.S. Patent No. 4,543,283 to Curtze et al. describes a glazing unit comprising a glass substrate and a laceration inhibiting shield supported by and extending over what would otherwise be an exposed interior surface of the substrate. A gasket or frame member composed of a synthetic polymer extends around a major portion of the periphery of the glass substrate and laceration shield, and is adhered to the marginal edge surfaces of each, the gasket having been polymerized in situ adjacent such periphery, and having assumed, through the autogenous mechanism incident to its polymerization and cure, intimate contact with the portions to which it is adhered.

U.S. Patent No. 5,556,667 to Teranishi discloses a method of forming a water-resistant film on a transparent panel such as an automobile window glass panel by applying a coating solution to a surface of the transparent panel, applying a solvent to a surface of a region not to be coated in partly overlapping relation (boundary region) to the coating solution applied to the region to be coated, drying the applied coating solution and solvent, and thereafter baking the coating solution into a water-resistant film.

U.S. Patent No. 6,316,059 to VanderPutten et al., describes a method of providing a metal pattern on a glass substrate in an electroless process without using photo-resist layers and organic solvents. As part of the electroless process a silane layer is removed by irradiation with actinic radiation by an ArF excimer laser, an oxygen plasma, or preferably a UV ozone treatment. The method also requires use of a palladium (Pd) sol, as Pd particles stabilized with water-soluble polymers do not absorb on glass surfaces.

FR 2793889 To Anderson et al., describes a transparent substrate having anti-reflective coatings on at least one surface formed from thin dielectric layers with alternating high and low refractive indices. At least one layer with a high refractive index includes modified titanium dioxide to decrease the refractive index to 2.40 or lower.

U.S. Patent No. 4,983,459 to Franz et al., describes a method, and the article made by such method, wherein a glass substrate is provided with a durable non-wetting surface by treatment with a perfluoroalkyl alkyl silane and a fluorinated olefin telomer.

U.S. Patent No. 5,763,892 to Kizaki et al., describes utilizing a dielectric barrier discharge excimer lamp for emitting UV light for a predetermined time period in order to supply a prescribed amount of ultraviolet energy to a substrate. The on/off time of the barrier discharge excimer lamp is controlled so as to maintain UV energy emissions at a constant level, and to avoid excessive temperature rise in the interior of an irradiator. Lamp output can be stabilized quickly by this method of operation whereby the time for different treatment steps is reduced.

U.S. Patent No. 5,131,967 to Tweadey et al., describes a method of making a laminated glazing unit having a metal coating on a laminated ply, and then removing a peripheral portion of the metal coating by exposure to a laser beam. Such edge deletion of the metal coating allows the subsequent lamination process to be carried out and the edges of the laminated unit to be well sealed, so that it is environmentally durable, and minimizes degradation of the integrity of the unit due to progressive edge corrosion of the metal coating which might otherwise occur.

U.S. Patent No. 4,931,125 to Volkmann et al., describes a method for adhesively bonding a first body to a second body, the first body comprising a non-metallic substrate and a filler, the second body comprising a substrate, metallic or non-metallic. The first body or the filler is pretreated by exposure to an energy beam to form projections on the non-metallic substrate by evaporation of the substrate material or the filler. The second body can be untreated, pretreated by an energy beam, or pretreated in another manner. An adhesive can then be applied to the pretreated area, and the first body adhered to the second, the bond created said to be stronger due to the projections formed on the first and/or second body by pretreatment.

Summary of Applicant's Position

The Examiner has rejected one or more of claims 23-38 under at least 16 combinations of references. In no instance has the Examiner relied on combining less than 3 references as a basis for rejecting such claims. More often, 4-6 references are combined to support those rejections. Applicant respectfully submits that the Examiner has resorted to hindsight in her detailed analysis of the present application. The need to combine three, four, five, or even six references to reject applicant's claims clearly indicates as much.

First, applicant would draw attention to page 1, paragraph 2, of the specification, which discusses the safety benefits of hydrophobic coatings on a vehicle window when contacted by water. Applicant submits that, logically, the only way such a benefit could accrue is for the hydrophobic coating to be on the surface of the window "exposed to the exterior of the vehicle," where it is contacted by rainfall, road spray, snow and the like, and is quickly shed by the hydrophobic coating to improve the driver's vision through such window. Also, please see the attached July 1997 report on hydrophobic coatings prepared by the University of Michigan Transportation Research Institute.

Secondly, applicant believes it is clear that the Curtze et al., reference is directed to a structure intended to be placed on the surface of a vehicle window exposed to the interior of a vehicle, i.e., the passenger compartment. Applicant is particularly familiar with the Curtze et al. reference, as Libbey-Owens-Ford Company is now known as Pilkington North America, Inc., the assignee in the present application. The interior location is necessary for the invention of the Curtze et al. reference to fulfill its function as an anti-laceration, anti-ejection shield. The coating noted by the Examiner as having the composition of a hydrophobic coating is present, applicant submits, as an anti-abrasion coating to minimize scratching of the interior surface during cleaning rather than for any purpose related to possible hydrophobic properties.

One skilled in the art would further recognize that a structure such as is disclosed in the Curtze et al. reference would not be durable enough to withstand the abrasive effects of windshield wipers, snow scrapers and the like to which a structure on an exterior surface would be exposed.

With regard to the Tweadey et al. reference, one skilled in the art would recognize that the purpose of the invention of the Tweadey et al. reference is to provide "a reliable effective and efficient method of improving the environmental durability of laminated glazing units having metal-based transparent, electrically conductive film stacks for solar load reduction and/or electrical heating in view of their potential for edge corrosion resulting from prolonged exposure to certain environmental conditions." (Tweadey, col. 3, lines 43-49) (emphasis added).

One skilled in the art would understand that hydrophobic coatings are not metal-based, and are therefore not susceptible to corrosion upon exposure to "certain environmental conditions." To the contrary, hydrophobic coatings are intended to be exposed to the environment, and must be, in order to fulfill their water-shedding purpose. Therefore, one skilled in the art would not be motivated to use the disclosure of Tweadey et al. to remove non-metal based, non-corrosive coatings from a glass substrate.

With respect to Volkmann et al., Kizaki et al., Van Der Putten et al., Anderson, Yoshinori et al., Franz et al. and Teranishi et al., and combinations thereof, applicant notes that claims 23-38 recite irradiating hydrophobic coatings on an area of a surface of a vehicle glazing (see, page 2, line 23 to page 3, line 2) with UV radiation preferably having a dominant wavelength in the range of 100-200 nm (see, for example, page 2, lines 21-22), thus removing the coatings. The hydrophobic coatings referred to herein cause water which comes into contact with the coating on an exterior surface of a vehicle glazing to bead readily and run off quickly so as not to obscure the outward vision of the occupants of the vehicle (see Background; page 1, lines 10-18).

After carefully studying the cited references, the applicant can find nowhere in one or proper combinations of such cited references where at least the above-stated limitations (irradiating hydrophobic coatings on an exterior surface of a vehicle glazing with radiation in the range of 100-200 nm), then adhering an item to an area of an exterior surface of a vehicle glazing (claims 23-33) or utilizing electro-mechanical means to provide relative movement between a source of UV radiation and a hydrophobic coating (claims 34-38) are taught or suggested.

Therefore, applicant respectfully submits that claims 23-38 of the present application are patentable over the cited references as the inventions defined thereby are not suggested therein, nor is there any suggestion or motivation to modify or combine these references' teachings in order to teach or suggest the claimed limitations, as required by 35 USC §103. Consequently, the applicant respectfully submits that claims 23-38 of the present application are patentable over such cited references and that claims 23-38 of the present application are patentable over such cited references and that claims 23-38 should be allowed thereover.

Specific Grounds for Rejection

a) The Examiner has rejected claims 23-24, and 26-33 under 35 USC §103(a) as being unpatentable over Yoshinori et al., in view of Curtze et al. and Teranishi et al. The Yoshinori, et al. reference, based on the small amount of which is available in the English language, is believed to disclose a method of partially removing a functional coating. Part of the area of the substrate coated is protected to avoid exposure to UV light. The portion of the coating which is exposed to UV light is broken down to generate ozone, which ozone is utilized in a later film removal step.

Applicant notes that one of the advantages of the method of the present invention is that no masking or other protective method is required, due to the precision with which the short wavelength UV light may be directed onto the coated substrate from the excimer lamp. Applicant further notes that ozone generation is not part of the method of the present invention which is necessary or desirable therefor.

As described previously, applicant submits that the Curtze et al reference is directed to an anti-laceration, anti-ejection shield comprising a sheet of polymeric material applied in a specific manner on the surface of a vehicle window exposed to the interior of a vehicle.

By contrast, the hydrophobic coating removed by the method of the present invention is provided on the exterior surface of a vehicle window, so the hydrophobic coating can serve its intended purpose of causing water, in whatever physical form, to be more efficiently shed of the vehicle window, either by wind action, or by mechanical means, such as windshield wipers.

Accordingly, applicant submits that one skilled in the art would not be motivated to combine the Yoshinori and Curtze references to arrive at the present invention, nor would the present invention be achieved if they were combined.

The Examiner has further cited the Teranishi et al. reference which describes a method of forming a variable-thickness water-repellent coating on a glass substrate, the variable thickness occurring in a so-called bondary region, and leaving an uncoated region, as well. Applicant notes that this references makes no mention of removing the coating, or using UV light to do so. Applicant respectfully submits that one skilled in the art would not be motivated to combine Teranishi with Yoshinori and Curtze to achieve a method of removing a hydrophobic coating using an excimer lamp for at least the reasons discussed herein. Therefore, claims 23-24 and 26-33 are believed to be patentable over the cited references.

b) For at least the reason that claim 25 depends from patentable claim 23, applicant submits that claim 25 is likewise patentable.

c) For at least the reason that claims 34-35 and 37-38 depend directly or indirectly from patentable claim 23, applicant submits that claims 34-35 and 37-38 are likewise patentable.

d) For at least the reason that claim 36 depends indirectly from patentable claim 23, applicant submits that claim 36 is likewise patentable.

e) The Examiner has rejected claims 23-34 and 26-33 under 35 USC §103(a) as being unpatentable over Teranishi in view of Curtze and Yoshinori and/or Vander Putten. For at least the reasons discussed above, applicant submits that one skilled in the art would not be motivated to combine Teranishi, Curtze and Yoshinori to achieve the invention of the present application, nor would the present invention be achieved if they were combined.

The additional reference, Vander Putten et al., describes a method of providing a metal pattern on a glass substrate by an electroless process which is said not to require photo-resist layers and organic solvents. As part of the process, a silane layer is removed by irradiation with actinic radiation, the source of which radiation may be an

ArF excimer laser, an oxygen plasma, or preferably a UV ozone treatment. The method also requires use of a palladium (Pd) sol, as Pd particles stabilized with water-soluble polymers do not absorb on glass surfaces. The method is said to be particularly suitable for the manufacture of the black matrix on a passive plate for an LCD, or on panels of other flat color displays, such as flat cathode ray tubes.

First, Vander Putten et al. fails to supply any of the above-noted deficiencies of Teranishi, Curtze and Yoshinori.

Moreover, one skilled in the art would recognize that an excimer laser, as described in Vander Putten et al., is significantly different from an excimer lamp, in that the intensity of the light emitted is much greater with the laser than with the excimer lamp. Thus, the mechanism by which the laser works is likewise different than with the excimer lamp. In the case of the present invention, it is likely that with the high temperatures generated by the intensity of the laser light, the coating would be simply burned off, whereas, with the excimer lamp, the temperatures generated are much lower and the excimer lamp desirably relies on selectively breaking chemical bonds, rather than simply destroying the coating altogether. Applicant submits that one skilled in the art would thus not be motivated to choose a laser for the purpose of the present invention, nor would an excimer lamp be appropriate for many purposes for which a laser might be used. Applicant notes that excimer lasers are also much more expensive than excimer lamps, and so would limit the feasibility of using a laser in a production process as is envisioned with the method of the present invention.

For all these reasons, applicant submits that the addition of Vander Putten to the Teranishi, Curtze and Yoshinori reference does not overcome the deficiency left by

Teranishi, Curtze and Yoshinori to achieve the invention of the present application, nor would one skilled in the art be motivated to make such a combination.

Therefore, applicant respectfully submits that claims 23-24 and 26-33 are patentable over the cited reference, singly or in combination.

f) For at least the reason that claim 25 depends from patentable claim 23, applicant submits that claim 25 is likewise patentable.

g) For at least the reason that claims 34-35 and 37-38 depend directly or indirectly from patentable claim 23, applicant submits that claims 34-35 and 37-38 are likewise patentable.

h) For at least the reason that claim 36 depends indirectly from patentable claim 23, applicant submits that claim 36 is likewise patentable.

i) The Examiner has rejected claims 23-24 and 26-33 under 35 USC §103(a) as being unpatentable over Anderson et al. in view of Curtze et al. and Yoshinori et al and/or Vander Putten et al.

For reasons previously noted, application submits that claims 23-24 and 26-33 are patentable over the Curtze et al, Yoshinori et al. and Vander Putten et al. references, singly, or in combination.

The additional reference, Anderson et al., describes a substrate having a multi-layer film stack deposited thereon, such that the thin layer coatings are of alternating high and low refractive indices. In this configuration, the film stack exhibits anti-reflective properties. At least one high refractive index layer includes modified titanium dioxide to decrease the refractive index somewhat. Other coating stacks described may exhibit properties such as hydrophobicity.

Applicant submits, however, that the description of Anderson et al. adds nothing to the combination of references cited to allow it to achieve the invention of the present application. The reference makes no mention of removing the coating described, or using UV light to do so.

Accordingly, applicant submits that claims 23-24 and 26-33 are patentable over Anderson et al., in view of Curtze et al. and Yoshinori et al. and/or Vander Putten et al.

j) For at least the reason that claim 25 depends from patentable claim 23, applicant submits that claim 25 is likewise patentable.

k) For at least the reason that claims 34-35 and 37-38 depend directly or indirectly from patentable claim 23, applicant submits that claims 34-35 and 37-38 are likewise patentable.

l) For at least the reason that claim 36 depends indirectly from patentable claim 23, applicant submits that claim 36 is likewise patentable.

m) The Examiner has rejected claims 23-24 and 26-33 under 35 USC §103(a) as being unpatentable over Franz et al, in view of Curtze et al., and Yoshinori et al. and/or Vander Putten, et al.

For the reasons previously discussed, applicant submits that claims 23-24 and 26-33 are patentable over Curtze et al., Yoshinori et al., and/or Vander Putten, et al., either singly, or in combination.

With regard to the additional reference, Franz et al., a method for making a durable non-wetting surface and the article made thereby, is described. Such coating is a perfluoroalkyl alkyl silane and a fluorinated olefin telomer. The coated glass is said to exibit a high water contact angle. Applicant can see no way that one skilled in the art could utilize the information contained in Franz et al. to overcome the deficiencies of Curtze et al., Yoshinori et al. and/or Vander Putten et al. to achieve the invention of the subject application, as it makes no mention of removing the coating described, nor using UV light to do so.

Therefore, applicant respectfully submits that claims 23-24 and 26-33 are patentable over Franz et al., Curtze et al, Yoshinori et al., and/or Vander Putten et al., singly, or in combination.

n) For at least the reason that claim 25 depends from patentable claim 23, applicant submits that claim 25 is likewise patentable.

o) For at least the reason that claims 34-35 and 37-38 depend directly or indirectly from patentable claim 23, applicant submits that claims 34-35 and 37-38 are likewise patentable.

p) For at least the reason that claim 36 depends indirectly from patentable claim 23, applicant submits that claim 36 is likewise patentable.

q) For at least the reason that claim 25 depends from patentable claim 23, applicant submits that claim 25 is likewise patentable.

r) For at least the reason that claims 34-35 and 37-38 depend directly or indirectly from patentable claim 23, applicant submits that claims 34-35 and 37-38 are likewise patentable.

s) For at least the reason that claim 36 depends indirectly from patentable claim 23, applicant submits that claim 36 is likewise patentable.

t) For at least the reason that claim 36 depends indirectly from patentable claim 23, applicant submits that claim 36 is likewise patentable.

CONCLUSION

As claims 23-24 and 26-33 are patentable for the reasons discussed, and as claims 25 and 34-38 depend directly or indirectly from independent claim 23, applicant submits claims 25 and 34-38 are likewise patentable. An expeditious determination by the Board to that effect is respectfully requested.

Respectfully submitted,

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CLAIMS APPENDIX

23. A method of adhering an item to an area of a surface of a vehicle glazing comprising:

providing a vehicle glazing having an exterior surface exposed to the exterior of a vehicle, the exterior surface having a hydrophobic coating disposed thereon;

irradiating the hydrophobic coating on the area of the exterior surface of the vehicle glazing with UV radiation having a dominant wavelength in the range of 100 to 200 nm, thus substantially removing the hydrophobic coating disposed on the area of the exterior surface of the vehicle glazing; and

adhering the item to the area of the exterior surface of the vehicle glazing.

24. The method of claim 23, wherein the hydrophobic coating is chosen from a group consisting of polysiloxane, polyfluorosiloxane, and diamond-like carbon.

25. The method of claim 23, wherein the dominant wavelength is approximately 172 nm.

26. The method of claim 23, wherein a water contact angle that is greater than 100 degrees is realized on the area of the surface of the vehicle glazing prior to irradiating the area of the surface of the vehicle glazing for 5-120 seconds or less, and a

water contact of the vehicle glazing following the irradiating of the area of the surface of the vehicle glazing.

27. The method of claim 23, further comprising:

applying an adhesive promoting primer to the area of the surface of the vehicle glazing from which the hydrophobic coating has been removed; and

applying an adhesive to the area of the surface of the vehicle glazing from which the hydrophobic coating has been removed.

28. The method of claim 27, wherein the adhesive promoting primer comprises silane and the adhesive is chosen from a group consisting of a cyanoacrylate, urethane, epoxy, acrylic, hot melt silicone, and pressure sensitive adhesive.

29. The method of claim 23, wherein the item comprises an elastomeric member.

30. The method of claim 29, wherein the elastomeric member comprises a gasket.

31. The method of claim 23, wherein the item comprises a vehicular hardware device.

32. The method of claim 31, wherein the vehicular hardware device comprises a fastening device.

33. The method of claim 31, wherein the vehicular hardware device comprises a mounting device.

34. The method of claim 23, for selectively removing a hydrophobic coating comprising:

providing a surface being exposed to the exterior of the vehicle;

providing a source of UV radiation having a dominant wavelength in the range of 100 to 200 nm;

utilizing electro-mechanical means to provide relative movement between a source of UV radiation and the hydrophobic coating to irradiate the area of the surface of the hydrophobic coating, thus selectively removing the hydrophobic coating and adhering an item to the area from which the hydrophobic coating has been removed.

35. The method of claim 34, wherein the hydrophobic coating is chosen from a group consisting of polysiloxane, polyfluorosiloxane, and diamond-like carbon.

36. The method of claim 34, wherein the dominant wavelength is approximately 172 nm.

37. The method of claim 34, wherein the electro-mechanical means comprises a robot arm.

38. The method of claim 37 wherein the electro-mechanical means further comprises a vision system in communication with the robot arm.

Evidence Appendix

(1) Specification of the present application, page 1, paragraph 2. This paragraph was present in the application as filed and was entered into the record upon the filing of the application. Arguments relating to this paragraph were presented in the amendment of September 27, 2004, which was entered into the record by the Examiner subsequent to the Request for Continued Examination dated October 18, 2004 and acknowledged by the Examiner in her paper dated January 7, 2005.

(2) Report on hydrophobic coatings July 1997, by the University of Michigan Transportation Research Institute. This report was submitted by applicant in the amendment of May 9, 2005, on page 13, which amendment was entered by the Examiner and acknowledged in the Office Action dated July 18, 2005.

Related Proceedings Appendix

None

METHOD OF USING SHORT WAVELENGTH UV LIGHT TO SELECTIVELY REMOVE A COATING FROM A SUBSTRATE AND ARTICLE PRODUCED THEREBY

BACKGROUND

A method of removing a selected portion of a coating from a substrate is disclosed. More particularly, a method of removing a functional organic coating, for example, a coating having hydrophobic properties, with short wavelength ultraviolet (UV) light from a non-conductive substrate is disclosed.

Various types of coatings are often applied to non-conductive substrates such as glass to impart different properties to the substrate. One such property which may be imparted to a substrate, such as glass, by a coating, is that of hydrophobicity. Hydrophobic coatings cause water to bead readily and run off quickly. One application where this property is useful is in the field of vehicle glazing. Application of a hydrophobic coating to a glazing in a vehicle, such as an automobile windshield, backlight or sidelight can, by its properties, cause water which comes into contact with the coating to form into beads and quickly run off the glazing so as not to obscure the outward vision of the occupants of the vehicle. Particularly for the operator of the vehicle, clearer vision is a safety benefit.

Much effort is expended in applying such hydrophobic coatings to a substrate, such as a vehicle glazing, to ensure that the coating strongly adheres to the substrate. It is, clearly, undesirable for the coating to begin to peel off the substrate, both from a functional and an aesthetic viewpoint.

It may be desirable, however, in some cases, to intentionally remove the coating from the substrate in selected areas. Such selective removal may be desirable, for example, if one wishes to adhere an item to the substrate. In the case of vehicle glazings, it is often desirable to adhere one or more gaskets to portions of the peripheral edge of the glazing. It might also be desirable to adhere an item of hardware, such as a fastening device, a mounting device, or the like, in a particular location on the glazing.

Typically, hydrophobic coatings do not readily allow adhesive materials to adhere to them. So, in order to adhere a gasket or an item of hardware to the substrate, the coating must be

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16. Abstract

This experiment evaluated potential benefits of hydrophobic coating of windshields under simulated conditions of use. The main independent variables were hydrophobic treatment, participant age, and time of day. The dependent measures were minimum visual angle resolved and response time. The results indicate that the hydrophobic coating improved visual performance, decreasing the minimum visual angle resolved by almost 34% and reducing the response time by more than one second. In practical terms, visual acuity improved in the treated-nighttime condition to approximately the level of acuity in the untreated-daytime condition.

This experiment showed that hydrophobic coatings can result in significantly improved driver visual performance without negatively affecting response time. However, this experiment did not address the durability or longevity of these products, as the hydrophobic coating was only tested when it was newly applied (and therefore could be expected to be near peak performance). Benefits associated with hydrophobic coatings are likely to diminish with time and wear (more or less slowly depending on durability), unless the coating is reapplied.

17. Key Words	18. Distribution Statement
hydrophobic coatings, windshield, visual acuity, visual angle, response time, rain	Unlimited

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CONTENTS

INTRODUCTION

Several hydrophobic coating products for motor vehicle windows are commercially available. Hydrophobic coatings are generally liquid polymers that bind with motor vehicle glazing. These transparent coatings act as water repellents, causing rain, and other accumulated moisture, to bead up. Aided by airflow caused by wind and vehicle motion, the resulting beads of water run off the vehicle's windshield and other windows. The beading and ease with which the beads are cleared are thought to lead to improved driver visual performance due to reduced optical distortion. In other words, not having to look through a sheet of moisture should result in a clearer image.

Most, if not all, of the commercially available hydrophobic coating products claim to aid drivers' visual performance. Yet, there exists no research in the open literature to substantiate the claims of improved visual performance, or any other benefits for that matter, associated with the use of hydrophobic coatings on the windshields of motor vehicles. While there are instances of specific product evaluations in popular magazines, these evaluations only provide anecdotal support for improved visual performance. The anecdotal support is largely in the form of improved visibility through the windshield, even without the use of windshield wipers, as well as visibility benefits when applied to the side and rear windows (which generally lack wiper mechanisms).

The purpose of this experiment was to quantify the effects of this class of products on visual performance under simulated conditions of use. More specifically, this experiment examines the minimum visual angle resolved and response time to targets viewed through a motor vehicle windshield for the following main independent variables:

- hydrophobic treatment (treated versus untreated),
- time of day (daytime versus nighttime), and
- participant age.

This experiment was performed under conditions of simulated rain and simulated wind effects associated with vehicle motion. Although the effects under real driving/raining conditions may differ from those obtained under the simulated conditions, the directions of the effects can be expected to be the same. Visual acuity is one of several possible measures of visual performance that could have been investigated in this study. Other measures include low-luminance detection, visual comfort, and visual scanning efficiency. However, the distortions typical of water film on window glass suggested that visual acuity is particularly likely to show a benefit of hydrophobic coatings. While there may be other benefits as well, visual acuity seemed a god candidate for the first, rather exploratory study.

Although the specific task used in this experiment is probably a relatively pure measure of visual acuity, participants were not given time limits for individual trials. Because of the dynamic character of the stimulus situation (including simulated wind and rain, as well as the action of windshield wipers) it is probably possible for participants to improve their performance by allocating more observation time to each trial. Therefore response time was measured, as well as minimum visual angle resolved, to insure that we had a comprehensive measure of relative visual performance across conditions.

This experiment did not address the durability or longevity of these products, as the hydrophobic coating was only tested when it was newly applied (and therefore could be expected to be near peak performance). The effects of hydrophobic coatings on driver visual acuity are likely to diminish with time and wear (more or less slowly, depending on durability).

METHOD

Participants

Thirty-two individuals participated in the study, 16 participants each in a younger group and an older group. The younger participants were between the ages of 20 and 30, and the older participants were between the ages of 60 and 70. Each group consisted of eight men and eight women. While taking part in the study, all participants wore the same corrective lenses, if any, that they would normally wear when driving. Measures of participant visual acuity (corrected acuity for those with corrective lenses) were recorded using an OPTEC 2000 vision tester. Measures of visual acuity ranged from 20/13 to 20/40 for the younger participant group (median = 20/19), and 20/13 to 20/50 for the older participant group (median = 20/22.5).

Apparatus

Stimuli. Participants viewed a series of 12 Landolt C targets from a distance of 38.1 m (125 ft) across an asphalt-paved lot (Figure 1). The Landolt C recognition task is a common measure of visual acuity. Performance on the Landolt C task is determined by the smallest gap size in the letter "C" a participant can detect when the gap is presented in one of four possible locations, separated by 90 degrees (up, down, left, or right). The stroke width of the character is kept equal to the gap size, and the height of the character is five times the gap size/stroke width. The range of gap sizes, and the associated subtended visual angles, of the targets are presented in Table 1. The target gap size, and stroke width, ranged from 4 to 33.5 mm (0.36 to 3.02 minutes of arc).

Table 1
Stimulus gap size and associated subtended visual angle.

Stimulus	Gap Size (mm)	Visual Angle (min)
1	4.0	0.36
2	5.4	0.49
3	6.6	0.60
4	8.1	0.73
5	10.0	0.90
6	11.6	1.05
7	14.3	1.29
8	16.9	1.52
9	20.0	1.80
10	24.6	2.22
11	29.4	2.65
12	33.5	3.02

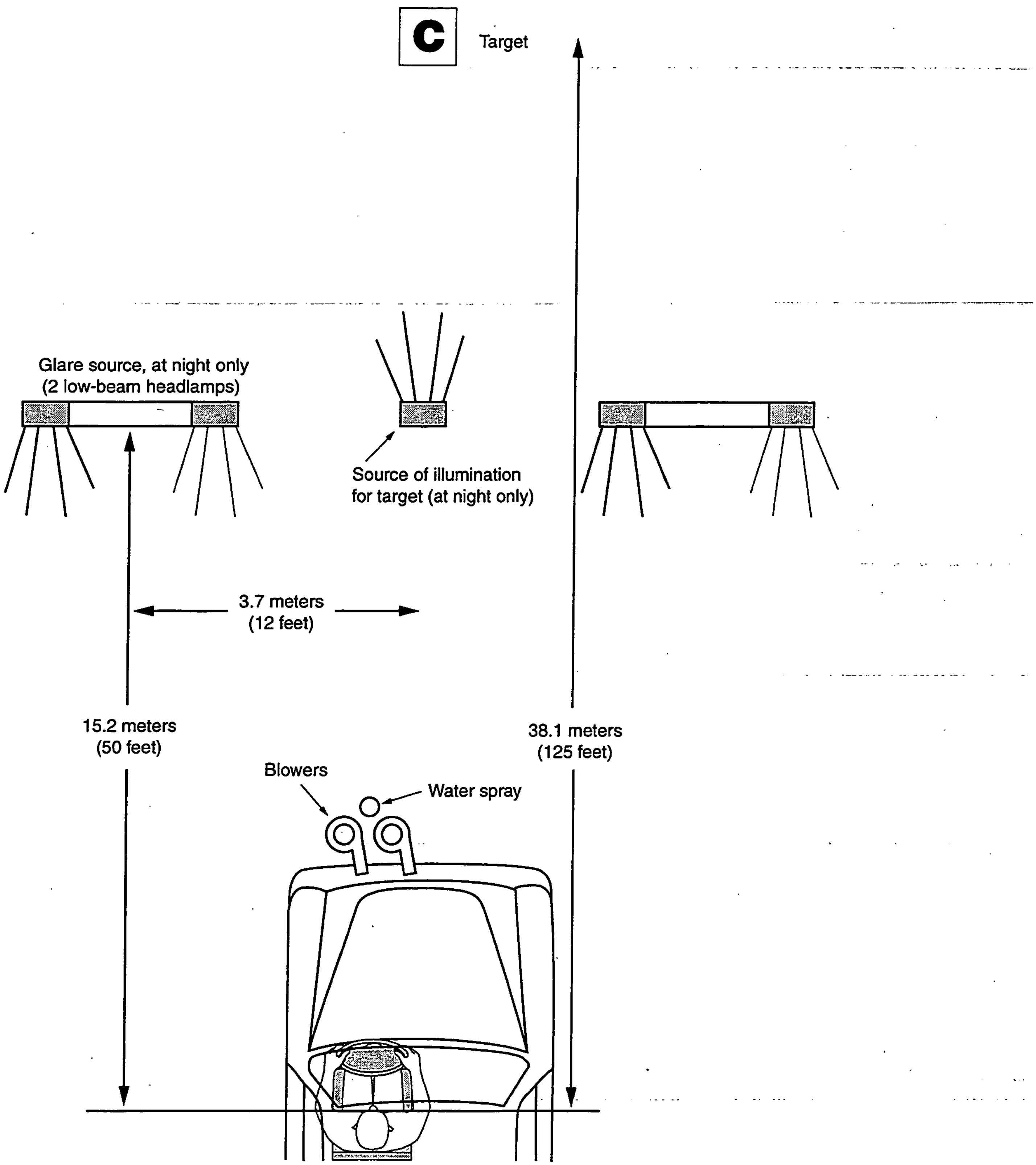

Figure 1. Overhead diagram of the experimental setup (distances are not to scale).

Participants viewed the targets while seated in either the driver's or the passenger's seat of a research vehicle, a 1992 compact with 36,000 km on the odometer. The center of the target was 1200 mm above the asphalt surface, and in line with the center of the vehicle. The target was therefore approximately 0.5 degrees to the right of straight ahead when the participant was seated on the driver's side, and 0.5 degrees to the left of straight ahead when the participant was seated on the passenger's side. The targets were constructed of retroreflective sheeting affixed to square aluminum plates that were 305 mm on each side. The "C" was made of white retroreflective sheeting and the background was made of green retroreflective sheeting. These materials were selected in order to simulate the appearance of roadway signs.

Simulated Rain and Wind. Rain and wind were simulated in this experiment. Rain was simulated by spraying water onto the vehicle's windshield. The resulting coverage was uniform over the area of the windshield through which participants could view the target. The rate at which water was applied could be varied (either 10 or 12 L/min), and the patterns of coverage were similar for the two rates. Both levels of water flow appeared to be comparable to that experienced while driving in a natural, moderate-to-heavy rainfall.

In order to simulate the wind, which normally aids in removing the beaded water from the windshield of a vehicle in motion, two leaf blowers were mounted on the front of the vehicle. These blowers produced a wind speed of about 58 km/h (36 mph), as measured on the exterior of the windshield at the participant's line of sight to the target. The apparatus for the simulated rain and wind could be positioned on either the driver's or passenger's side of the vehicle. It was positioned low on the hood in order not to obstruct the participant's view of the target or of the glare from headlamps in the nighttime testing.

Independent Variables

Hydrophobic Treatment. Hydrophobic treatment of the windshield was a within-subject variable. The windshield of the research vehicle was thoroughly cleaned with isopropyl alcohol, and new windshield wiper blades were installed. One half of the windshield was then treated with a commercially available hydrophobic coating, following the manufacturer's directions for application. Additional treatments were applied after every 4 - 6 hours of testing in order to maintain the hydrophobicity at near peak performance. The manufacturer's directions were also followed for additional applications. One half of the participant group received the hydrophobic treatment on the driver's side of the windshield, and the other half received the hydrophobic treatment on the passenger's side. When the treated side of the windshield was changed, the hydrophobic treatment was thoroughly removed (in accordance with the manufacturer's recommendations), and the windshield was examined to ensure that no residual treatment remained.

Participant Age. There were two age groups, younger and older. Sixteen participants were between the ages of 20 and 30 (mean = 25.8 years), and 16 were between the ages of 60 and 70 (mean = 65.6 years).

Flow Rate. Flow rate was a between-subjects variable. Sixteen participants performed the Landolt C task while water was sprayed onto the windshield at a rate of 10 L/min, and the remaining 16 participants received a flow rate of 12 L/min. The two rates of simulated rain are believed to be appropriate amounts of water for the selected windshield wiper setting (low). Both levels of flow rate appeared as a "moderate to heavy rainfall." All testing was performed without active natural precipitation. The vehicle's windshield wipers ran continuously during the experiment at the rate of 1.5 s for a complete cycle (i.e., bottom of the windshield to full extension and back to the bottom).

Time of Day. Time of day was a between-subjects variable. Sixteen individuals participated in the experiment during the daytime, under partly cloudy to cloudy conditions, and the remaining 16 participated at night. The targets were illuminated by a standard U.S. low-beam headlamp during the nighttime condition, energized by a voltage-regulated power supply set at 12.8 V. This headlamp was located 22.8 m from the target, 0.6 m above the pavement, and positioned in line with the centerlines of the target and the research vehicle. The luminance of the target for the nighttime condition, as viewed from the position of the participants (through the research vehicle windshield) was approximately 2.5 cd/m^2 for the green background and 6.4 cd/m^2 for the white letter C. Luminance measurements were taken using the 38.1 m viewing distance and oversized samples of the same retroreflective material used in producing the stimuli.

Glare. Within the nighttime condition, the presence or absence of glare was an additional within-subject variable. The glare sources consisted of two pairs of standard U.S. low-beam headlamps. The two sets of headlamps were located 3.7 m (centerline of headlamp set to centerline of vehicle) on either side of the research vehicle, at a distance of 15.2 m, and 0.6 m above the pavement. The center-to-center separation between headlamps in a set was 1.2 m. Only one set of headlamps, those located on the side closest to the participant, was energized at a time. These headlamps were energized by voltage-regulated power supplies set at 12.8 V. The level of illumination reaching the participants' eyes was maintained at approximately 1 lux.

Dependent Variables

The purpose of this experiment was to quantify the effects of hydrophobic treatment on visual performance under simulated conditions of use. It was believed a priori that the hydrophobic treatment would influence visual performance, more specifically affecting the minimum visual angle resolved. However, the visual acuity task used here is likely to be affected both by the participants fundamental visual acuity, and the amount of time devoted to the task. By measuring the response time to targets, in both treated and untreated conditions, it was possible to evaluate whether any apparent differences in acuity could be attributed to differences in subjects' self-imposed time limits.

Visual Acuity - Landolt C Recognition. Performance on the Landolt C task is determined by the smallest gap size (minimum visual angle) in the letter "C" a participant can detect when the gap is presented in one of four possible locations, separated by 90 degrees (up, down, left, or right). The range of gap sizes, and the associated subtended visual angles used, were previously presented in Table 1.

Response Time. Response time in the Landolt C task was defined as the time from when the stimulus was first exposed to when the participant reported the orientation of the gap (up, down, left, or right). Response times were collected manually for each trial by a researcher located in the seat behind the participant. Participants were not aware that response times were being recorded.

Design

Daytime Condition. Participants in the daytime condition took part in two blocks of trials, one seated on the driver's side and one seated on the passenger's side. Each block consisted of 32 trials, excluding practice trials. The total time it took one participant to complete the two daytime blocks (64 trials, plus practice trials) was approximately 25 minutes. There was an equal number of participants (2) for each combination of hydrophobic treatment, participant age group and flow rate. The sex of participants was also balanced over these conditions (one male and one female in each combination).

Nighttime Condition. Participants in the nighttime condition took part in four blocks of trials, two seated on the driver's side and two seated on the passenger's side (once each with and without oncoming glare). Each block consisted of 32 trials, excluding practice trials. The total time it took one participant to complete the four nighttime blocks (128 trials, plus practice trials) was approximately 40 minutes. As in the daytime condition, there was an equal number of participants (2) for each combination of hydrophobic treatment, participant age group and flow rate, and there was one male and one female for each combination of these variables. The order of glare treatment was partially counterbalanced across participants.

Procedure

The staircase method, a psychophysical method used to determine absolute and difference thresholds, was employed. Each condition began by presenting the largest stimulus gap size, 33.5 mm. When the orientation of the target was correctly identified, then the subsequent stimulus was 40% smaller. This process of reductions, in step size by 40%, continued until a participant incorrectly identified the orientation of the target (a reversal). The first trial after this reversal always began with the stimulus that was one level of gap size (20 %) larger than the incorrectly identified target. Starting with the first trial after the initial reversal, a series of 32 trials was presented with gap size increasing by one step (20%) after each trial on which a participant's response was incorrect, and decreasing by one step (20%) after each correct response. The reversals, the points at which the order of increasing or decreasing stimulus size changed, were considered estimates of the participant's threshold. The average of these transition points over the 32 trials was considered the participant's threshold for a given condition.

One experimenter placed the stimuli in a frame, mounted on a tripod. A second experimenter recorded the stimuli presented, whether the participant correctly identified the stimulus orientation (communicating via CB radio with the participant), and instructed the first experimenter as to which stimulus to present next. A third experimenter, seated behind the participant, provided instructions for the task, recorded response times, and ensured that the prescribed protocol was followed. The specific instructions to participants were as follows:

> *In this study you will be seated in a car and asked to look at targets located across a parking lot. The targets are always the letter "C," but vary in orientation and size. You will be asked to state which direction the opening in the letter "C" is pointed; up, down, left, or right. Even if you can not accurately judge the orientation of the target, you must still guess.*
>
> *Example:*

> *Water will be sprayed on the windshield to simulate rain, and blowers will be turned on to simulate wind. You will be asked to report the orientation of the targets to the experimenters using a hand-held CB radio. Please respond as rapidly as possible after the experimenter has stepped out from in front of the target.*
>
> *We recognize that this is a difficult task, but we ask you to try as hard as possible to correctly identify the orientation of the targets presented.*

RESULTS

Glare Conditions

The glare condition, examined only during nighttime testing, was found in preliminary analyses not to influence performance on either dependent measure, either as a main effect or as part of any higher order interactions. Consequently, the data were collapsed across glare conditions, thereby eliminating glare as a variable, but retaining time of day as an independent variable.

Analyses of Covariance

Two analyses of covariance (ANCOVA) were performed, one each for the two dependent measures of visual acuity and response time. ANCOVA is a procedure that uses statistical control to remove the effects of a variable, also known as a covariate, that is believed to be correlated with an independent measure, particularly where strict experimental control of the covariate is difficult or impractical. ANCOVA determines whether there are differences among groups or conditions observed in the experiment, over and above those differences that could be accounted for by the covariate. The covariate in these analyses was the standardized score (z) of visual acuity obtained with the OPTEC 2000 vision tester, as it was expected to be correlated with participant age, and may affect the measure of visual acuity used in the experimental task (Landolt C recognition). All means reported here are adjusted means from the ANCOVAs.

Response Time. Of the four main-effects (hydrophobic treatment, participant age, flow rate, and time of day), and all possible interactions, only the main effect of hydrophobic treatment was statistically significant, $F(1,16) = 29.8, p \leq 0.0001$. Specifically, the response times of participants to the Landolt C recognition task were shorter when performed with a hydrophobically treated windshield (mean = 3.0 s) than for the same task in the untreated condition (mean = 4.2 s). This result is illustrated in Figure 2.

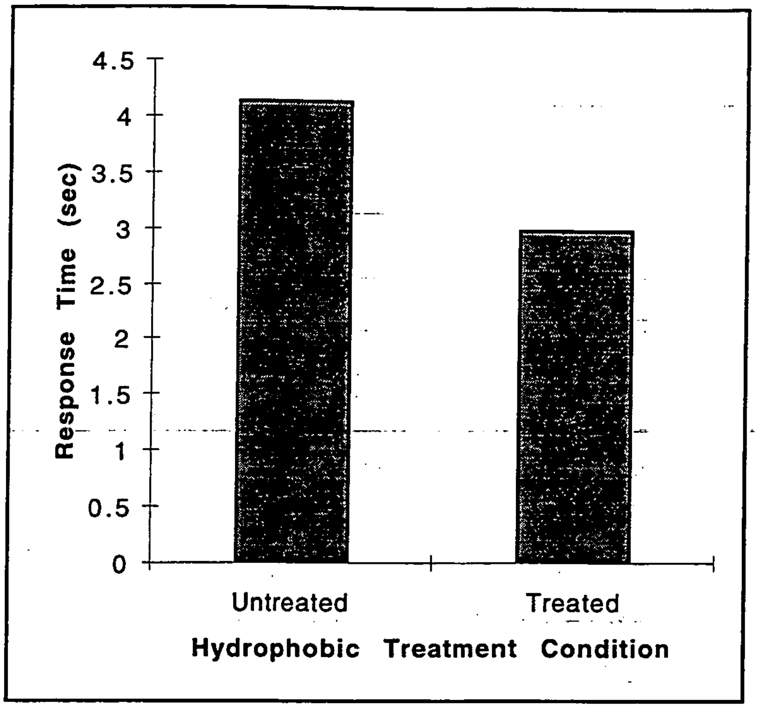

Figure 2. Response time by hydrophobic treatment condition.

Visual Acuity. Hydrophobic treatment and time of day had statistically significant effects on visual acuity, $F(1,16) = 85.5, p \leq 0.0001$ and $F(1,16) = 17.4, p = 0.0007$, respectively. Participants were able to detect targets of smaller subtended visual angle through a hydrophobically treated windshield (mean = 1.0 min) than through one that was untreated (mean = 1.5 min) (Figure 3), and also detect targets of smaller subtended visual angle in the daytime condition (mean = 0.9 min) as opposed to nighttime (mean = 1.5 min) (Figure 4).

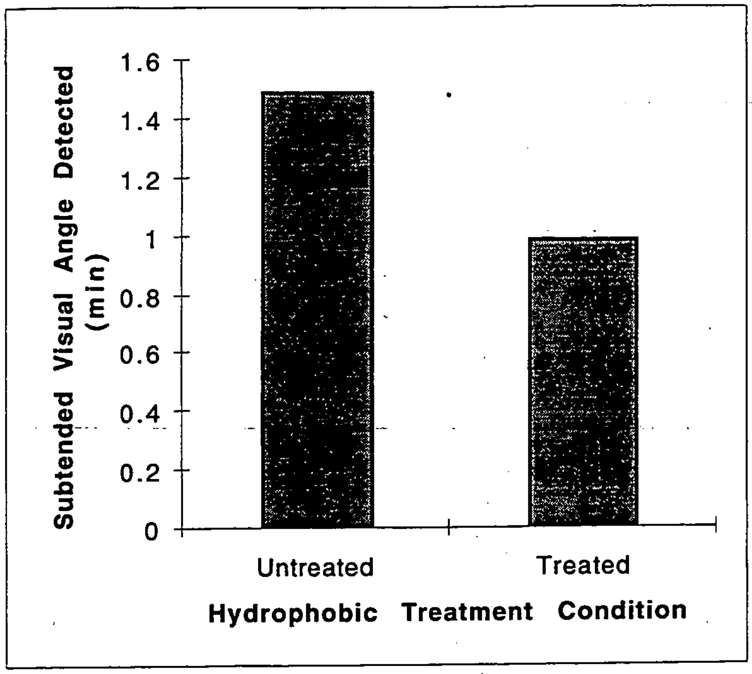

Figure 3. Visual acuity by hydrophobic treatment condition.

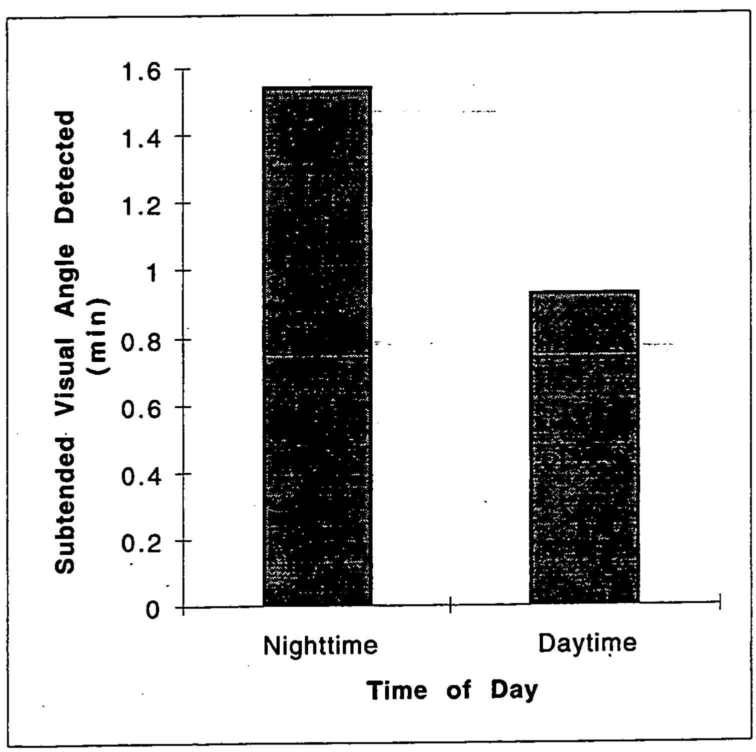

Figure 4. Visual acuity by time of day.

Several two-way interactions were statistically significant. Figure 5 illustrates the interaction of hydrophobic treatment condition and time of day, $F(1,16) = 21.8$, $p = 0.0003$. A Student-Newman-Keuls post-hoc analysis of the results showed participants were better at detecting targets of smaller subtended visual angle in the treated-daytime condition than in the remaining three conditions. The treated-nighttime condition was not statistically different from the untreated-daytime condition ($\alpha = 0.05$). The untreated-nighttime condition was statistically different from the other three conditions and resulted in the poorest overall performance.

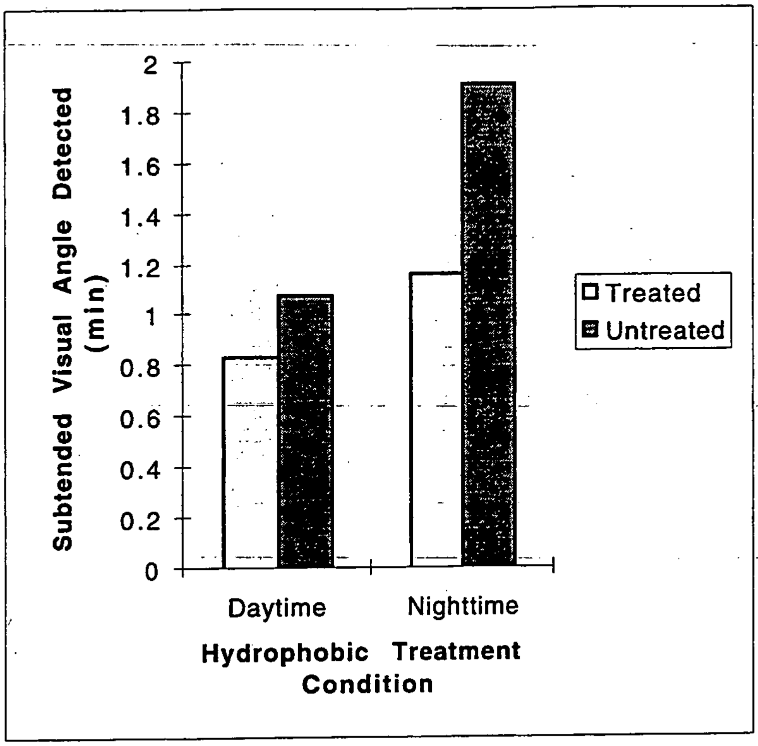

Figure 5. Visual acuity by hydrophobic treatment condition and time of day.

Figure 6 shows the interaction of participant age and time of day $F(1,16) = 7.0$, $p = 0.018$. A Student-Newman-Keuls post-hoc analysis of the results showed that both younger and older participants were better at detecting targets in the daytime condition than in the nighttime condition, and that, in the nighttime condition, younger participants were better than older individuals. The difference between younger and older participants in the daytime condition was not significant.

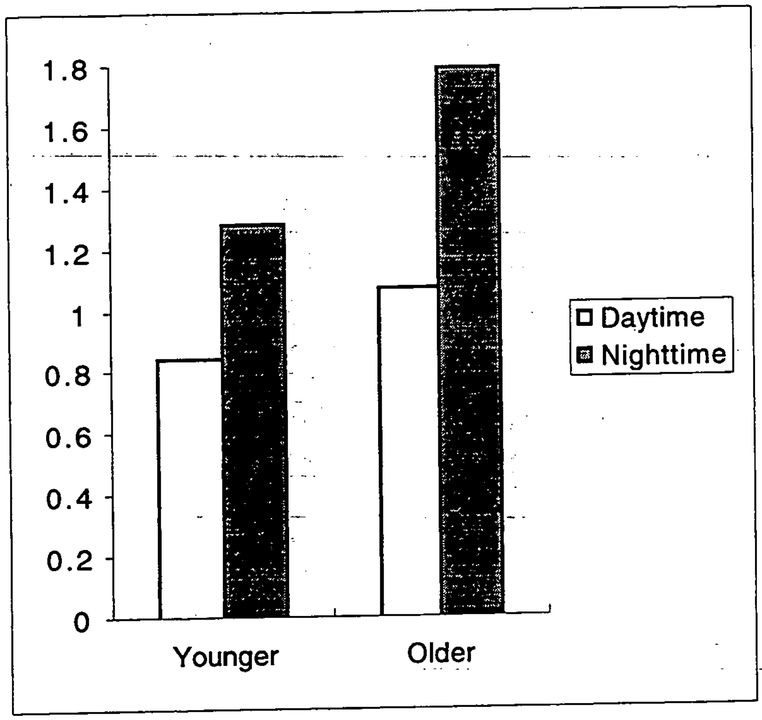

Figure 6. Visual acuity by age and time of day.

Figure 7 shows the interaction of water flow rate and time of day, $F(1,16) = 6.5, p = 0.022$. A Student-Newman-Keuls post-hoc analysis of the results showed that the pairwise comparison between the daytime and nighttime treatments with high flow rate (12 L/min) were not significantly different from one another. The three remaining pairwise comparisons between treatments were significant.

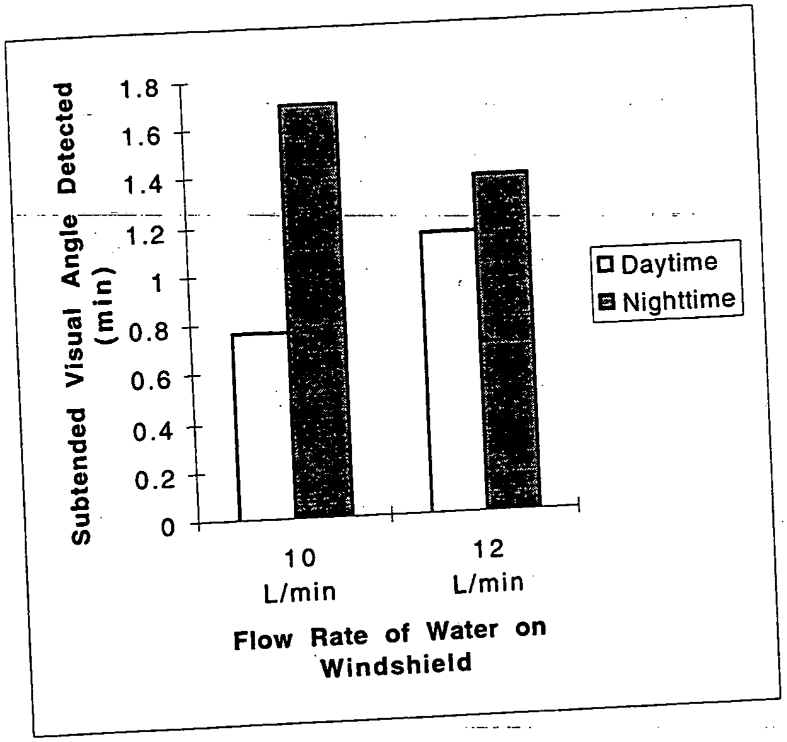

Figure 7. Visual acuity by flow rate and time of day.

In addition, two three-way interactions were statistically significant. Figure 8 shows the interaction of hydrophobic treatment, time of day, and participant age, $F(1,8) = 6.2, p = 0.024$, and Figure 9 shows the interaction of hydrophobic treatment, time of day, and flow rate, $F(1,8) = 6.2, p = 0.024$. It should be noted, particularly in Figure 8, that the benefit of hydrophobic treatment appears to be proportional (18% - 42% improvement) to visual performance without hydrophobic treatment.

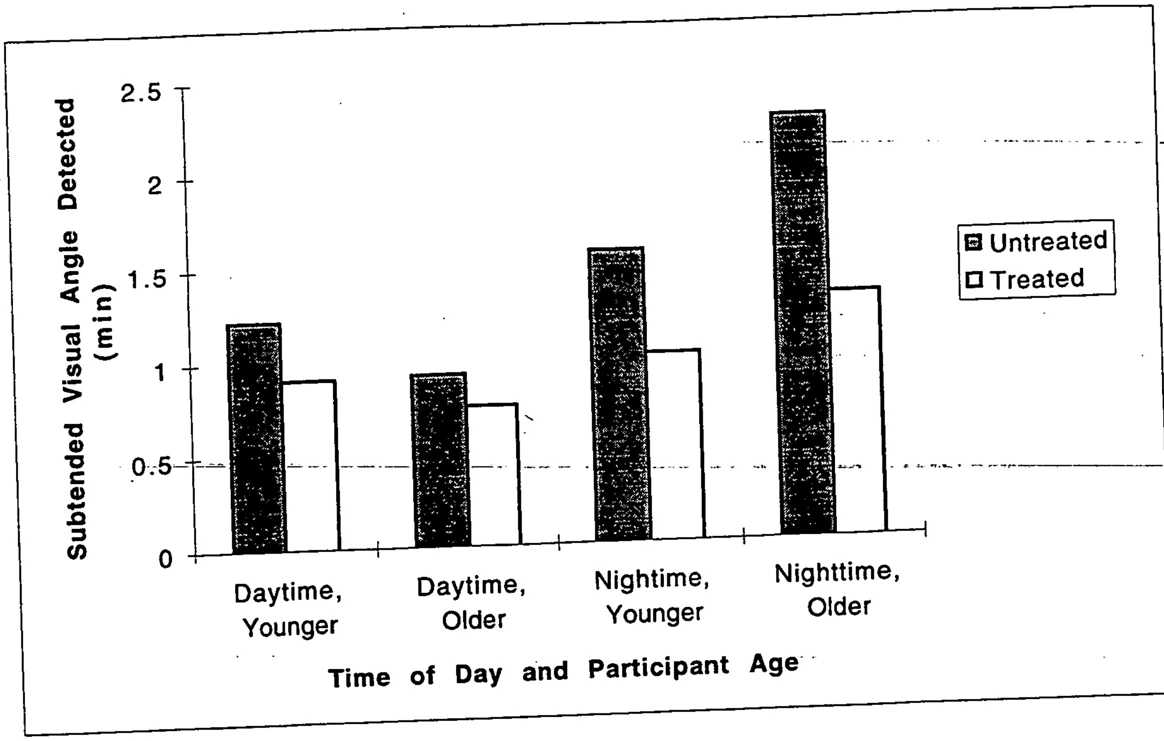

Figure 8. Visual acuity by treatment condition, age, and time of day.

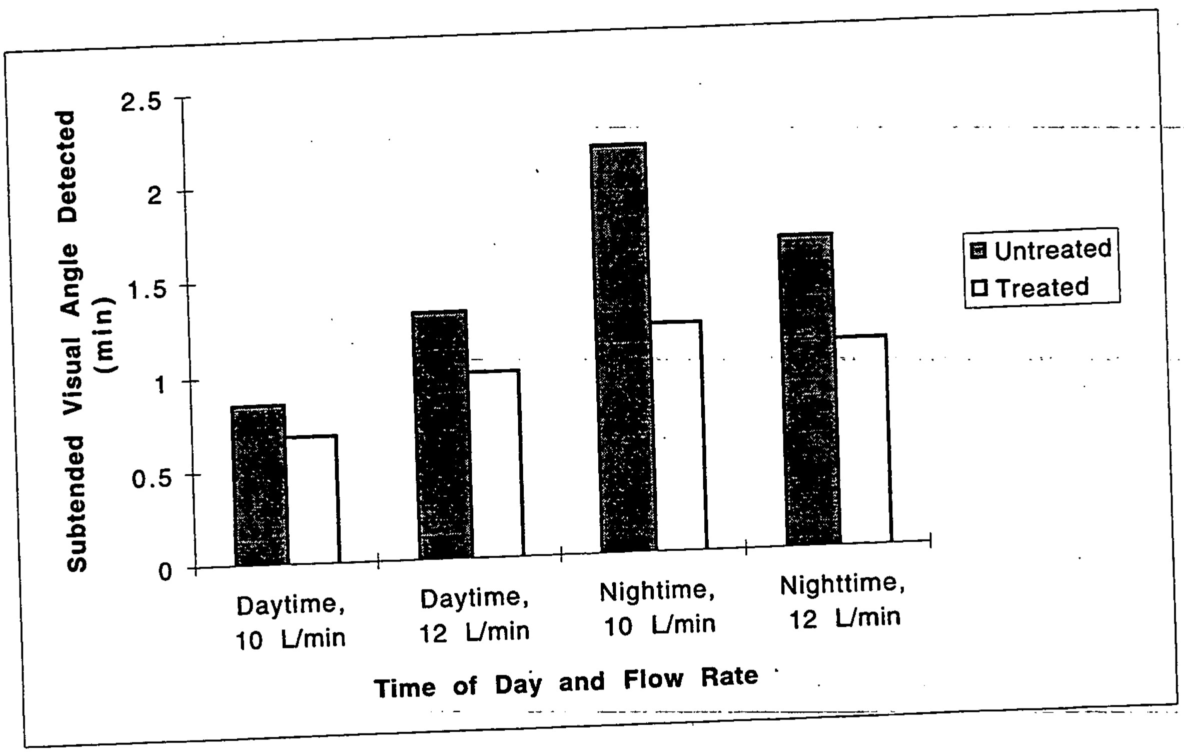

Figure 9. Visual acuity by treatment condition, time of day, and flow rate.

DISCUSSION

The application of hydrophobic treatment to the windshield of an automobile, under simulated rainy-driving conditions, resulted in significantly improved visual acuity and decreased response time to recognize a simple target. The improvement in response time was, on average, greater than one second: equivalent to more than 27 m of travel at 100 km/h. The improvement in visual acuity was also rather large (approximately 34% in terms of the minimum visual angle resolved). By way of comparison, visual acuity improved in the treated-nighttime condition to a level that was not significantly different from performance in the untreated-daytime condition (Figure 5). Although these findings require validation under conditions of actual rain, and in real-world driving conditions, the preliminary indications are that the introduction of hydrophobic coatings to automotive windshields can substantially improve driver visual acuity and response time (Figures 2 and 3).

Despite the illumination of the target by a headlamp in the nighttime condition, visual acuity in the daytime condition was significantly better than at night (Figure 4). It is in the nighttime condition, particularly for older participants, that the hydrophobic treatment appears to provide the greatest benefit in terms of comparison with an untreated condition (Figures 5 and 8). Performance by both age groups was influenced by the time of day and treatment conditions. However, younger participants consistently showed better performance than older participants (Figures 6 and 8).

Although there was no main effect of flow rate, the interaction of time of day and flow rate produced an unexpected result. Participants were able to detect targets of smaller subtended visual angle in the nighttime condition with the higher level of water flow (Figure 7). The reason for this result is unclear. The remaining statistically significant effects, three-way interactions, all showed improved visual acuity resulting from the hydrophobic treatment (Figures 8 and 9).

The experimental conditions in the present study simulated moderate to heavy amounts of rainfall, windshield wipers on at all times, and a moderate traveling speed. This experiment did not examine the scenario of very light rainfall, windshield wipers off, and a low traveling speed. In the later scenario, increased nighttime glare may result from water beading that is not rapidly removed. In addition, the current study was only performed under circumstances where the hydrophobic coating was applied as specified by the manufacturer, and believed to be near peak performance. Similar levels of improvement in visual acuity may not be observed with worn, or less effective, applications of hydrophobic coating. The durability of these treatments, and the resulting effects on visual acuity, remain to be investigated.

CONCLUSION

This experiment evaluated potential visual acuity benefits of hydrophobic coating products under simulated conditions of use. In general, this experiment showed that these products appear to significantly improve driver visual acuity and response time. However, this experiment did not address the durability or longevity of these products, as the hydrophobic coating was only tested when it was expected to be near peak performance. Therefore the benefits associated with hydrophobic coatings that were demonstrated here may diminish with time and wear, more or less slowly, depending on the durability of different hydrophobic treatments. Additional testing, under real-world driving conditions, where actual precipitation and durability are examined, would be desirable.